

FORM PTO-1390 (REV. 11-2000)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 450118-02282
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371			U.S. APPLICATION NO. (if known see 37 C.F.R. 1.5) 097/869897
INTERNATIONAL APPLICATION NO. PCT/JP00/00013	INTERNATIONAL FILING DATE 5 JANUARY 2000	PRIORITY DATE CLAIMED 7 JANUARY 1999	
TITLE OF INVENTION ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE ESTIMATING DEVICE, ERROR RATE ESTIMATING METHOD, RECEIVING METHOD USING ERROR RATE ESTIMATING METHOD, AND INFORMATION RECORDING MEDIUM			
APPLICANT(S) FOR DO/EO/US Atsushi INOMATA, Tamotsu IKEDA			

Applicants herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

- ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
- ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
- ☒ This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).
- ☐ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
- ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - ☐ is attached hereto (required only if not communicated by the International Bureau).
 - ☒ has been communicated by the International Bureau.
 - ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
- ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
- ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - ☐ are attached hereto (required only if not communicated by the International Bureau).
 - ☐ have been communicated by the International Bureau.
 - ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - ☒ have not been made and will not be made.
- ☐ A English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
- ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
- ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

- ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
- ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
- ☒ A FIRST preliminary amendment.
- ☐ A SECOND or SUBSEQUENT preliminary amendment.
- ☐ A substitute specification.
- ☐ A change of power of attorney and/or address letter.
- ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
- ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
- ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
- ☒ Other items or information:
 PCT/RO/101 PCT/ISA/210
 PCT/IB/301, 304, 308, 332
 30 Sheets of Drawings, 1 Page Abstract

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09869897, 101501

U.S. APPLICATION NO. 09/869897 (1.50)

INTERNATIONAL APPLICATION NO.
PCT/JP00/00013

ATTORNEY'S DOCKET NO.
450118-02282

21. ☒ The following fees are submitted

CALCULATIONS PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):

Neither international preliminary examination fee (37 CFR 1.482)
nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO
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CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$
Total Claims	22 - 20 =	2	x \$18.00	\$ 36.00
Independent Claims	9 - 3 =	6	x \$80.00	\$ 480.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)				+ \$270.00
TOTAL OF ABOVE CALCULATIONS =				\$
<input type="checkbox"/> Applicant claims small entity status. See 37 C.F.R. 1.27. The fees indicated above are reduced by 1/2.				+
SUBTOTAL =				\$ 1,376.00
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$
TOTAL NATIONAL FEE =				\$ 1,376.00
Fee for recording the enclosed assignments (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property				+ \$ 0.00
TOTAL FEES ENCLOSED =				\$ 1,376.00
				Amount to be refunded: \$
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JC18 Rec'd PCT/PTO 0 6 JUL 2001

450118-02282

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Inomata, et al.

Filed.: Filed Concurrently Herewith

Title of Invention: ERROR RATE ESTIMATING DEVICE, RECEIVER
USING ERROR RATE ESTIMATING DEVICE, ERROR
RATE ESTIMATING METHOD, RECEIVING METHOD
USING ERROR RATE ESTIMATING METHOD, AND
INFORMATION RECORDING MEDIUM

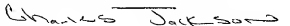
745 Fifth Avenue
New York, NY 10151

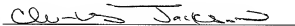
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PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Box Patent Application (35 U.S.C. 111)
Washington, D.C. 20231

Sir:

Before the issuance of the first Office Action, please amend the above-identified application as follows:

09/869897 "10151"

IN THE TITLE

Please amend the title as follows:

ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE ESTIMATING
DEVICE, ERROR RATE ESTIMATING METHOD, RECEIVING METHOD USING ERROR
RATE ESTIMATING METHOD, AND INFORMATION RECORDING MEDIUM

IN THE SPECIFICATION

Please delete the paragraphs beginning at page 24, line 13 through page 30, line 22.

Please replace the paragraph beginning at page 1, line 10 with the following rewritten paragraph:

The present invention relates to an error rate estimating device and a receiver using the error rate estimating device, an error rate estimating method and a receiving method using the error rate estimating method, and an information recording medium, more particularly relates to an error rate estimating device and method for determining an error rate on a channel using the number of times of normalization performed by a circuit finding a state metric, a receiver using the error rate estimating device, an error rate estimating method and a receiving method using the error rate estimating method, and an information recording medium.

Please replace the paragraph beginning at page 17, line 12 with the following rewritten paragraph:

Still another object of the present invention is to provide an information recording medium provided with software for executing a method for realizing the above error rate estimating method and decoding method.

Please replace the paragraph beginning at page 17, line 16 with the following rewritten paragraph:

performed when generating a state metric, within a predetermined time and an estimation instruction for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted when the count instruction is executed.

Please replace the paragraph beginning at page 19, line 20 with the following rewritten paragraph:

According to a fourth aspect of the present invention, there is provided an error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate estimating device provided with a judging means for judging a transmission system or coding rate of the signal; a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimating means for estimating the error rate for each signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means; and a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.

Please replace the paragraph beginning at page 20, line 17 with the following rewritten paragraph:

According to a fifth aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate estimating method comprising (1)

determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.

5. (Amended) An error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal,

said error rate estimating method comprising:

a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimating step of estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step.

9. (Amended) An information recording medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein said control information includes:

a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimation instruction for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted when said count instruction is executed.

10. (Amended) An information recording medium as set forth in claim 9, wherein the estimation instruction estimates the error rate based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

11. (Amended) An information recording medium as set forth in claim 9, wherein the estimation instruction inserts the number of times of normalization counted by the counting means into a predetermined function.
12. (Amended) An information recording medium as set forth in claim 9, wherein the count instruction counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate.
13. (Amended) An error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, said error rate estimating device provided with:
- a judging means for judging a transmission system or coding rate of the signal;
 - a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;
 - an estimating means for estimating the error rate for each signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means; and
 - a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.
16. (Amended) An error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, said error rate estimating method comprising:
- a judging step of judging a transmission system or coding rate of the signal;

20. (Amended) An error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating device comprising:

a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimating means for estimating the error rate for each signal by the number of times of normalization counted by the counting means;

a multiplying means for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating means for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an outputting means for adding and outputting the error rate for each signal output from the multiplying means.

22. (Amended) An information recording medium for providing information for control executed by a receiver receiving and decoding a signal modulated by a plurality of transmission systems or coding rates sent through a channel,

said control information including:

a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step;

a multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step

for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an output instruction for adding and outputting the error rate for each signal output from the multiplying step.


REMARKS

The specification has been amended, claims 23-38 have been cancelled, and claims 1, 5, 9, 10, 11, 12, 13, 16, 19, 20, and 22 have been amended. All of these amendments reflect the amendments to the International Application made under PCT Article 34. The filing fee has been calculated based upon these new claims. The attached is captioned **“Version with markings to show changes made”** and indicate the changes that have been made herein.

Respectfully submitted,

FROMMER LAWRENCE & HAUG LLP
Attorneys for Applicant

By:


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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the title:

ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE ESTIMATING
DEVICE, ERROR RATE ESTIMATING METHOD, RECEIVING METHOD USING ERROR
RATE ESTIMATING METHOD, AND INFORMATION [PROVIDING] RECORDING
MEDIUM

In the specification:

Paragraph beginning at page 1, line 10 has been amended as follows:

The present invention relates to an error rate estimating device and a receiver using the
error rate estimating device, an error rate estimating method and a receiving method using the
error rate estimating method, and an information [providing] recording medium, more
particularly relates to an error rate estimating device and method for determining an error rate on
a channel using the number of times of normalization performed by a circuit finding a state
metric, a receiver using the error rate estimating device, an error rate estimating method and a
receiving method using the error rate estimating method, and an information [providing]
recording medium.

Paragraph beginning at page 17, line 12 has been amended as follows:

Still another object of the present invention is to provide an information [providing]
recording medium provided with software for executing a method for realizing the above error
rate estimating method and decoding method.

Paragraph beginning at page 17, line 16 has been amended as follows:

According to a first aspect of the present invention, there is provided an error rate
estimating device for estimating the error rate of an quadrature-modulated signal when decoding

the signal, the error rate estimating device provided with a counting means for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an estimating means for estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.

Paragraph beginning at page 18, line 12 has been amended as follows:

According to a second aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal, the error rate estimating method comprising (1) a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and (2) an estimating step (3) of estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step.

Paragraph beginning at page 19, line 8 has been amended as follows:

According to a third aspect of the present invention, there is provided an information [providing] recording medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein the control information includes a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an

Paragraph beginning at page 19, line 20 has been amended as follows:

Paragraph beginning at page 20, line 17 has been amended as follows:

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Paragraph beginning at page 21, line 15 has been amended as follows:

Paragraph beginning at page 23, line 18 has been amended as follows:

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sent through a channel, the control information including a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step; a multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

In the claims:

1. (Amended) An error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal,

the error rate estimating device provided with

counting means [(91; 101, 102, 103)] for counting the number of times of normalization, performed when generating a state metric within a predetermined time and

an estimating means ']'for estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.
5. (Amended) An error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal,

said error rate estimating method comprising:

a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimating step of estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step.

9. (Amended) An information [providing] recording medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein said control information includes:

a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimation instruction for estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted when said count instruction is executed.

10. (Amended) An information [providing] recording medium as set forth in claim 9, wherein the estimation instruction estimates the error rate based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

11. (Amended) An information [providing] recording medium as set forth in claim 9, wherein the estimation instruction inserts the number of times of normalization counted by the counting means into a predetermined function.
12. (Amended) An information [providing] recording medium as set forth in claim 9, wherein the count instruction counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate.
13. (Amended) An error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, said error rate estimating device provided with:
- a judging means [(62)] for judging a transmission system or coding rate of the signal;
- a counting means [(91)] for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;
- an estimating means [(92, 111)] for estimating the error rate for each signal [by the number of times of normalization] from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means; and
- a selecting means [(32, 33)] for selecting one of a plurality of error rates for each signal estimated by the estimating means.

16. (Amended) An error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, said error rate estimating method comprising:

a judging step of judging a transmission system or coding rate of the signal;

a counting step of counting the number of times of normalization, performed when a state metric is generated, for each of the plurality of transmission systems or coding rates;

an estimating step of estimating the error rate for each signal [by the number of times of normalization] from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step; and

a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

19. (Amended) An information [providing] recording medium for providing information for control executed by a receiver receiving a signal modulated by a plurality of transmission systems or coding rates sent through a channel, wherein said control information includes:

a judgement instruction for judging a transmission system or coding rate of the signal;

a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time;

an estimation instruction for estimating the error rate of the signal [by the number of times of normalization] from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or

each different coding rate based on the number of times of normalization counted in said count step; and

a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

20. (Amended) An error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating device comprising:

a counting means [(91)] for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimating means [(92)] for estimating the error rate for each signal by the number of times of normalization counted by the counting means;

a multiplying means [(111)] for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating means for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an outputting means [(32, 33)] for adding and outputting the error rate for each signal output from the multiplying means.

22. (Amended) An information [providing] recording medium for providing information for control executed by a receiver receiving and decoding a signal modulated by a plurality of transmission systems or coding rates sent through a channel,

said control information including:

a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step;

a multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

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DESCRIPTION

ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE
5 ESTIMATING DEVICE, ERROR RATE ESTIMATING METHOD,
RECEIVING METHOD USING ERROR RATE ESTIMATING METHOD, AND
INFORMATION PROVIDING MEDIUM

TECHNICAL FIELD

10 The present invention relates to an error rate
estimating device and a receiver using the error rate
estimating device, an error rate estimating method and a
receiving method using the error rate estimating method,
and an information providing medium, more particularly
15 relates to an error rate estimating device and method for
determining an error rate on a channel using the number
of times of normalization performed by a circuit finding
a state metric, a receiver using the error rate
estimating device, an error rate estimating method and a
20 receiving method using the error rate estimating method,
and an information providing medium.

BACKGROUND ART

At the present, in Japan, provision of a digital
broadcasting service using a successor to the BS4
25 scheduled to be launched as a broadcasting satellite is

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being discussed at the Radio Regulatory Council. In this digital broadcasting service, 8 SPK (Phase Shift Keying), QPSK (Quadrature PSK), and BPSK (Binary PSK) are defined as channel coding systems.

5 Figure 1 is a block diagram of an example of the configuration of a transmitter and a receiver. The transmitter 1 is comprised of a video, audio, or other information source 2, a coder 3, a puncturing unit 4, and a mapping unit 5. The information source 2 outputs data
10 to be coded and transmitted to the coder 3. The coder 3 performs trellis coding on input 1-bit data by the coding rate $R=1/2$ and outputs it to the puncturing unit 4 as a 2-bit coded word. The puncturing unit 4 punctures the input 2-bit data and outputs it to the mapping unit 5.
15 The mapping unit 5 assigns the input 2-bit coded word to one signal point among four signal points shown in Fig. 5 by an quadrature modulation system and outputs an I-signal and Q-signal of the signal point to a channel 6.

 A receiver 7 is comprised of a bit insertion unit 8,
20 a decoder 9, and decoded information 10. The bit insertion unit 8 inserts bits into the received signals (I, Q) input via the channel 6 and outputs them to the decoder 9. The decoder 9 performs trellis decoding on the input signal and outputs it as decoded information 10.

25 The decoded information 10 shows decoded data. An image

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and sound can be obtained by reproducing the decoded information 10 with a not shown reproducing apparatus.

Information of the state metric output from the decoder 9 is supplied to a monitoring circuit 11. The
5 monitoring circuit 11 determines an error rate on the channel 6 and outputs the information as error rate information 12. The error rate information 12, for instance, is used as data when adjusting the orientation of the antenna for receiving the data in a direction
10 giving the lowest error rate.

Figure 2 is a block diagram showing the configuration of a coder 3. The coder 3 is a convolutional coder. An input 1-bit data b_0 is coded to 2-bit data (c_1 , c_0) and output. The output 2-bit data c_1 ,
15 c_0 is generated by calculating the data b_0 by a processor comprising delay circuits 21 and 22 and exclusive OR circuits 23 and 24.

That is, the data b_0 is input to the delay circuit 21, the exclusive OR circuit 23, and the exclusive OR
20 circuit 24. The data b_0 input to the delay circuit 21 is delayed by one unit time and output to the delay circuit 22 and the exclusive OR circuit 23. The data input to the delay circuit 22 is further delayed for one unit time and output to the exclusive OR circuits 23 and 24. The
25 exclusive OR circuit 23 calculates the exclusive OR of

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the three bits of data, that is, the data b_0 currently input in the coder 3, the data input to the coder 3 one time unit before, and further the data input to the coder 3 two time units before, to generate the output data c_1 .

5 The exclusive OR circuit 24 calculates the exclusive OR of the data b_0 currently input in the coder 3 and the data input to the coder 3 two time unit before to generate an output data c_0 .

10 The output data (c_1 , c_0) output from the coder 3 are input to the puncturing unit 4 in this way. The puncturing unit 4 outputs the input data to the mapping unit 5 as is when outputting the data of the coding rate $R=1/2$ to the channel 6 and punctures the input data and outputs it to the mapping unit 5 when outputting data of
15 the coding rate $R=3/4$ to the channel 6.

 Figures 3A and 3B are views for explaining the puncturing. As shown in Fig. 3A, the puncturing unit 4 punctures the input data (c_1 , c_0) in accordance with the puncturing table shown in Fig. 3B and outputs the data
20 (p_1 , p_0).

 In the puncturing table shown in Fig. 3B, "1" shows the input data output as the data p_0 or data p_1 and "0" shows the input data not output (erased). For instance, the data shown in Fig. 4B is output when the data shown
25 in Fig. 4A is input.

That is, as shown in Fig. 4A, when data X_1 to X_6 are input as the input data c_1 and the data Y_1 to Y_6 are input as the input data c_0 to the puncturing unit 4, since these are input in the order of the data c_0 , c_1 , when the data are sequentially input in the order of Y_1 , X_1 , Y_2 , X_2 , ..., Y_6 , X_6 to the puncturing unit 4, as shown in Fig. 4B, the data X_1 , Y_3 , X_4 , and Y_6 are output as the output data p_1 and the data Y_1 , X_2 , Y_4 , and X_5 are output as the output data p_0 . Note that since the output data is output in the order of the data p_0 , p_1 , the data is output from the puncturing unit 4 in the order of Y_1 , X_1 , X_2 , Y_3 , Y_4 , X_4 , X_5 , and Y_6 .

The input data Y_1 , X_1 are output as output data p_0 , p_1 as is since they correspond to positions of the value 1 of the puncturing table, but the input data Y_2 is deleted since it corresponds to a position of a value 0 of the puncturing table. The next output data X_2 (corresponding to a position of a value 1 of the puncturing table) is output as the data p_0 . Below, in the same way, data corresponding to a position of a value 0 of the puncturing table are deleted and data corresponding to a position of a value 1 of the puncturing table are output.

The data output from the puncturing unit 4 in this way are mapped onto the signal points in the quadrature

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coordinate system based on the I-axis and Q-axis as shown in Fig. 5 by the mapping unit 5. The signal points are arranged at equal intervals 90 degrees apart. " p_1 " shown in Figs. 3A and 3B is the MSB (most significant bit) in the signal point assignment, while " p_0 " is the LSB (least significant bit) in the signal point assignment. That is, a signal point assignment may be expressed as (p_1 , p_0).

The data mapped by the mapping unit 5 is input to the bit insertion unit 8 of the receiver 7 through the channel 6. Figures 6A and 6B are views explaining bit insertion. Bit insertion is processing opposite to the puncturing performed in the puncturing unit 4, that is, processing for outputting received data as is to the decoder 9 when receiving data of the coding rate $R=1/2$ and inserting deleted data (bits) when receiving data of the coding rate $R=3/4$.

As shown in Fig. 6A, the bit insertion unit 8 inserts bits in the data (p'_1 , p'_0) from the transmitter 1 through the channel 6 in accordance with the depuncturing table shown in Fig. 6B and outputs the output data (c'_1 , c'_0). A value 1 of the depuncturing table shown in Fig. 6B indicates to output the input data as is, while the value 0 indicates to insert 0 (insert a bit).

When for example input data shown in Fig. 7A (data

output from the puncturing unit 4 and shown in Fig. 4B) is input to the bit insertion unit 8, the data shown in Fig. 7B is output. The data transmitted from the transmitter 1 is in the order of the data p_0, p_1 , so the order of input into the bit insertion unit 8 of the receiver 7 also becomes the data p'_0, p'_1 . Further, the order of the data output from the bit inserted unit 8 becomes the data c'_0, c'_1 .

Note that the data p'_0, p'_1 show the data p_0, p_1 output from the transmitter having the possibility of generation of error due to the effect of noise or distortion in the channel 6.

Therefore, the data X_2 input as the input data p'_0 is data corresponding to a position of a value 0 of the depuncturing table, so is output as the data c'_0 in a form with 0 inserted instead of the input data X_2 . The data X_2 is output as the data c'_1 . In this way, input data positioned at a value 0 is output with 0 inserted.

Data with a bit inserted by the bit insertion unit 8 in this way is output to the decoder 9.

Figure 8 is a block diagram of the inner configuration of the decoder 9. The decoder 9 is comprised of a branch metric generator 31 (hereinafter referred to as a "BM generator 31"), an add, compare, and select (ACS) circuit 32, and a path memory 33. The signal

input to the decoder 9 is first input to the BM generator 31 calculating the square of the Euclidean distance from a received signal point with the noise and distortion of the channel to a signal point to originally be received and generating the same as a branch metric. The branch metrics generated at the BM generator 31 are cumulatively added and compared in accordance with a convolutional coding trellis by the ACS circuit 32 to calculate the state metric of each state.

Figure 9 is a trellis transition diagram for explaining the calculation of a state metric performed by the ACS circuit 32. As the paths in the state 00 at the time $t+1$, two paths may be considered: the path of the case where the branch metric BM_{00} is selected at the state 00 at the time t and the path of the case where the branch metric BM_{11} is selected at a state 01 at the time t . The value obtained by adding the value of the branch metric BM_{00} to the state metric of the state 00 at the time t and the value obtained by adding the value of the branch metric BM_{11} to the state metric of the state 01 at the time t are compared and the path with the smaller value is used as the state metric of the state 00 at the time $t+1$.

Similarly, the state metrics of the states 01, 10, and 11 at the time $t+1$ are calculated.

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The ACS circuit 32, as described above, controls the path memory 33 while inferring the state transition at the coding side (transmission side). If there is no noise or distortion on the channel, the input signal matches with the original transmission signal point, so the BM generator 31 generates 0 for the branch metric relating to the transmission signal point and the square of the distance between the signal points for other branch metrics. Therefore, when these branch metrics are cumulatively added in accordance with the state transition diagram and the state metric calculated in the ACS circuit 32, the state metric remains 0 for the original path, but the state metric is a large value for other paths, so the transmission signal sequence can be inferred from this.

Here, consider the case where the input signal includes noise. Since the input signal is comprised of the original transmission signal point plus noise, the branch metric relating to the original transmission signal point does not always become 0 and has indefiniteness depending on the noise power. In the same way, for other branch metrics as well, the square of the distance between signal points also has indefiniteness depending on the noise power.

However, when the noise power is small, the ACS

circuit 32 cumulatively adds the branch metrics in accordance with the state transition diagram and calculates the state metric. Since the state metric is a small value for the original path, but the state metric has a large value for other passes, it is possible to estimate the transmission signal sequence.

Figure 10 is a block diagram of the configuration of the ACS circuit 32. The ACS circuit 32 is comprised of the state 00 generating unit 41, state 01 generating unit 42, state 10 generating unit 43, and state 11 generating unit 44 for finding the state metrics for the states 00, 01, 10, and 11. The state 00 generating unit 41 is comprised of adders 45-1 and 46-1 and a selector 47-1. The state metric of the state 00 and branch metric BM00 at the time t are input to the adder 45-1 and added. In the same way, the state metric of the state 01 and branch metric BM11 at the time t are input to the adder 46-1 and added.

The selector 47-1 compares the values input from the adder 45-1 and the adder 46-1 and outputs the smaller value to a register 48-1. The register 48-1 stores the value of the state metric of the state 00 at the time $t+1$, output from the selector 47-1, as a value at the time when finding the state metric of the state 00 at the next time $t+2$, and outputs it to the path memory 33.

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The state 01 generating unit 42 is comprised of the adders 45-2 and 46-2 and the selector 47-2. The state metric of the state 10 and branch metric BM10 at the time t are input to the adder 45-2 and added. The state metric of the state 11 and the branch metric BM01 at the time t are input to the adder 46-2 and added. The selector 47-2 compares the values input from the adder 45-2 and the adder 46-2 and outputs the smaller value to a register 48-2. The register 48-2 stores the value of the state metric of the state 01 at the time $t+1$, output from the selector 47-2, as a value at the time when finding the state metric of the state 01 at the next time $t+2$, and outputs it to the path memory 33.

The state 10 generating unit 43 is comprised of the adders 45-3 and 46-3 and the selector 47-3. The state metric of the state 00 and the branch metric BM11 at the time t are input to the adder 45-3 and added. The state metric of the state 01 and the branch metric BM00 at the time t are input to the adder 46-3 and added. The selector 47-3 compares the values input from the adder 45-1 and the adder 46-3 and outputs the smaller value to a register 48-3. The register 48-3 stores the value of the state metric of the state 10 at the time $t+1$, output from the selector 47-3, as a value at the time when finding the state metric of the state 10 at the next time

t+2, and outputs it to the path memory 33.

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The state 11 generating unit 44 is comprised of the adders 45-3 and 46-3 and the selector 47-4. The state metric of the state 10 and the branch metric BM01 at the time t are input to the adder 45-4 and added, while the state metric of the state 11 and branch metric BM10 at the time t are input to the adder 46-4 and added. The selector 47-4 compares the values input from the adder 45-1 and the adder 46-4 and outputs the smaller value to a register 48-4. The register 48-4 stores a value of the state metric of the state 11 at the time t+1, output from the selector 47-4, as the value at the time when finding the state metric of the state 11 at the next time t+2, and outputs it to the path memory 33.

15 However, the bit length in the above ACS circuit 32 is limited, so overflow occurs due to the addition of the branch metrics, therefore processing is necessary to prevent overflow from occurring. The processing to prevent overflow from occurring in this way is called "normalization". Figure 11 shows the configuration of the ACS circuit 32 for calculating a state metric while performing normalization.

25 In the configuration of the ACS circuit 32 shown in Fig. 11, the value output from the state 00 generating unit 41 is supplied to the register 48-1 through the

subtractor 51-1, the value output from the state 01 generating unit 42 is supplied to the register 48-2 through the subtracter 51-2, the value output from the state 10 generating unit 43 is supplied to the register 48-3 through the subtracter 51-3, and the value output from the state 11 generating unit 44 is supplied to the register 48-4 through the subtracter 51-4. The values output from the registers 48-1 to 48-4 are input to the path memory 33 and the minimum value processor 52.

The minimum value processor 52 calculates the minimum value of the state metrics output from the registers 48-1 to 48-4 and outputs the value to the subtracters 51-1 to 51-4, the path memory 33, and the monitoring circuit 11. The subtracters 51-1 to 51-4 subtract the value input from the minimum value processor 52 from the values input from the state generating units 41 to 44 respectively corresponding to the subtracters 51-1 to 51-4. In this way, normalization is carried out.

Figure 12 is a block diagram of the configuration of the monitoring circuit 11. The monitoring circuit 11 is comprised of an accumulator 61 and a table 62. The accumulator 61 cumulatively adds the values of the minimum state metric for a predetermined time and outputs the cumulative total to the table 62. The table 62 is comprised of a ROM (read only memory) and the like and

determines the noise of the channel by using a table establishing correspondence between a value output from the accumulator 61 and noise.

Figure 13 is a block diagram of the configuration of the accumulator 61. A timer 71 generates a pulse at a predetermined cycle and supplies the pulse to a minimum SM (status metric) value accumulator 72. The minimum SM value accumulator 72 receives as input the minimum value of the state metric output from the minimum value processor 52 (Fig. 11) and the value output and fed back from the minimum SM value accumulator 72. The value output from the minimum SM value accumulator 72 and the pulse generated at the timer 71 are supplied to the register 73.

The operation of the accumulator 61 shown in Fig. 13 will be explained referring to the timing chart in Figs. 14A to 14D. The pulse generated by the timer 71 (Fig. 14A) is a reset pulse for resetting the cumulative total of the minimum SM values. The minimum SM value accumulator 72 cumulatively adds the minimum SM values input between the pulse generated at a predetermined time t and the pulse generated at the next time $t+1$ and outputs the value to the register 73.

When the minimum SM value accumulator 72 receives as input a value such as shown in Fig. 14B as the minimum SM

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value, a cumulative value shown in Fig. 14C is output. That is, when receiving as input a pulse from the timer 71 at the time t , the minimum SM value accumulator 72 resets the cumulative total to 0. It then successively
5 cumulatively adds the minimum SM values input between t and $t+1$. Further, when a pulse from the timer 71 is input again at the time $t+1$, the cumulative total is reset to 0.

The register 73 stores the value input from the
10 minimum SM value accumulator 72 at the time when the pulse is input from the timer 71 and outputs the value to the table 62.

Figures 15A and 15B are views of an example of a table stored in the table 62. When the transmission
15 system is QPSK and the coding rate R is $\frac{1}{2}$, the magnitude of the transmission error rate (C/N) of data on the channel is judged in accordance with the table shown in Fig. 15A. When the transmission system is QPSK and the coding rate R is $\frac{3}{4}$, the magnitude of the transmission
20 error rate of the data on the channel is judged in accordance with the table shown in Fig. 15B.

Judging the error rate on the channel as described above required the minimum value processor 52 for calculating the value of the minimum state metric, the
25 minimum SM value accumulator 72 provided at the

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monitoring circuit 11 and cumulatively adding the output from the minimum value processor 52, and the register 73 for storing the cumulative total. There was the problem that these circuits (apparatuses) 52, 72, and 73 became
5 larger in circuit size along with an increase in the number of transmission signal points (number of states) transmitted from the transmitter 1 (four states in the above example).

Further, there was the problem that the calculation
10 time also increased along with an increase in the number of states. Furthermore, in the BS transmission system, it is being proposed to transmit using different transmission systems for time division. When a plurality of transmission systems are used, there was the problem
15 that, with the monitoring circuit 11 shown in Fig. 12, it became difficult to judge the transmission error rate.

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide an
20 error rate estimating device used for a receiver which enables a shortening of the calculation time and a reduction of the circuit scale by judging the error rate on a channel using the number of times of normalization performed in a circuit for finding a state metric.

25 Another object of the present invention is to

provide a receiver using the above error rate estimating device.

Still another object of the present invention is to provide an error rate estimating method enabling a shortening of the calculation time when judging the error rate on the channel using the number of times of normalization performed in a circuit for finding a state metric.

Still another object of the present invention is to
10 provide a decoding method using the above possible error
rate estimating method.

Still another object of the present invention is to provide an information providing medium provided with software for executing a method for realizing the above error rate estimating method and decoding method.

According to a first aspect of the present invention, there is provided an error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal, the error rate estimating device provided with a counting means for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an estimating means for estimating the error rate of the signal by the number of times of normalization counted by the counting means.

Preferably, the estimating means estimates the error rate based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

5 Alternatively, preferably the estimating means inserts the number of times of normalization counted by the counting means into a predetermined function.

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10 Alternatively, the counting means counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate.

According to a second aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when
15 decoding an quadrature-modulated signal, the error rate estimating method comprising (1) a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and (2) an estimating step (3) of estimating the
20 error rate of the signal by the number of times of normalization counted in the counting step.

Preferably, in the estimating step, the error rate is estimated based on a table establishing correspondence between the number of times of normalization and the
25 error rate on a channel.

Alternatively, preferably, in the estimating step, the number of times of normalization counted in the counting step is inserted into a predetermined function.

Alternatively, in the counting step, only the number
5 of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate is counted.

According to a third aspect of the present invention, there is provided an information providing
10 medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein the control information includes a count instruction for counting the number of times of normalization, performed when
15 generating a state metric, within a predetermined time and an estimation instruction for estimating the error rate of the signal by the number of times of normalization counted when the count instruction is executed.

According to a fourth aspect of the present invention, there is provided an error rate estimating device for estimating an error rate of a signal when
20 decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate
25 estimating device provided with a judging means for

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judging a transmission system or coding rate of the
signal; a counting means for counting the number of times
of normalization, performed when generating a state
metric, for each of the plurality of transmission systems
or coding rates; an estimating means for estimating the
error rate for each signal by the number of times of
normalization counted by the counting means; and a
selecting means for selecting one of a plurality of error
rates for each signal estimated by the estimating means.

10 Preferably, the selecting means selects the error
rate according to the transmission system or the coding
rate judged by the judging means.

15 Alternatively, preferably the selecting means
selects an error rate to be output by comparing a
plurality of error rates input with a predetermined
reference value.

20 According to a fifth aspect of the present
invention, there is provided an error rate estimating
method for estimating an error rate of a signal when
decoding a signal modulated by a plurality of
transmission systems or coding rates, the error rate
estimating method comprising (1) a judging step of
judging a transmission system or coding rate of the
signal; (2) a counting step of counting the number of
times of normalization, performed when a state metric is

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Alternatively, preferably, in the selecting step, an error rate to be output is selected by comparing a plurality of error rates input with a predetermined reference value.

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rate of the signal by the number of times of normalization counted in the count step; and a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

5 According to a seventh aspect of the present invention, there is provided an error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate
10 estimating device comprising a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimating means for estimating the error rate for each signal by
15 the number of times of normalization counted by the counting means; a multiplying means for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating means for a predetermined transmission
20 system or coding rate among the transmission systems or coding rates and multiplying with that value; and an outputting means for adding and outputting the error rate for each signal output from the multiplying means.

 According to an eighth aspect of the present
25 invention, there is provided an error rate estimating

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method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate estimating method comprising (1) a counting step of

5 counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; (2) an estimating step of estimating the error rate for each signal by the number of times of normalization counted in

10 the counting step; (3) a multiplying step of determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or

15 coding rates and multiplying with that value; and (4) an outputting step of adding and outputting the error rate for each signal output in the multiplying step.

According to a ninth aspect of the present invention, there is provided an information providing

20 medium for providing information for control executed by a receiver receiving and decoding a signal modulated by a plurality of transmission systems or coding rates sent through a channel, the control information including a count instruction for counting the number of times of

25 normalization, performed when generating a state metric,

for each of the plurality of transmission systems or coding rates; an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step; a

- 5 multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding
10 rates and multiplying with that value; and an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

- According to a 10th aspect of the present invention, there is provided a receiver for receiving and decoding a
15 signal which has been convolutionally coded, punctured, and quadrature-modulated, the receiver provided with a depuncturing means for performing processing reverse to the puncturing and a decoding means for decoding the above punctured quadrature-modulated data; the decoding
20 means having a branch metric calculating means for calculating a branch metric of the above punctured quadrature-modulated data, an adding, comparing, and selecting means having an error estimating means for estimating an error rate of a signal and adding and
25 comparing it for the calculated branch metric and for

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selecting a path with reference to the result of estimation by the error estimating means, and a path memory for outputting a signal metric in accordance with the path selected by the adding, comparing, and selecting means; and the error rate estimating means is provided with a counting means for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an estimating means for estimating an error rate of the signal by the number of times of normalization counted by the counting means.

According to an 11th aspect of the present invention, there is provided a decoding method for decoding a signal which has been convolutionally coded, punctured, and quadrature-modulated, the decoding method provided with (1) a depuncturing step for performing processing reverse to the puncturing and (2) a decoding step for decoding the above punctured quadrature-modulated data; the decoding step comprising (a) a step of calculating a branch metric of the above punctured quadrature-modulated data, (b) a step of estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for selecting a path with reference to the estimated error rate, and (c) a step of outputting a signal matrix in accordance with the selected path; and the step of

estimating the error rate of the signal comprises (i) a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and (ii) an estimating step of estimating an error rate of the signal by the number of times of normalization counted by the counting step.

According to a 12th aspect of the present invention, there is provided a receiver for receiving and decoding a signal which has been convolutionally coded, punctured, and quadrature-modulated, the receiver provided with a depuncturing means for performing processing reverse to the puncturing and a decoding means for decoding the above punctured quadrature-modulated data; the decoding means having a branch metric calculating means for calculating a branch metric of the above punctured quadrature-modulated data, an adding, comparing, and selecting means having an error estimating means for estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for selecting a path with reference to the result of estimation by the error estimating means, and a path memory means for outputting a signal matrix in accordance with the path selected by the adding, comparing, and selecting means; and the error rate estimating means is provided with a judging means for judging a transmission

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system or coding rate of the signal; a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimating
5 means for estimating the error rate for each signal by the number of times of normalization counted by the counting means; and a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.

10 According to a 13th aspect of the present invention, there is provided a decoding method for decoding a signal which has been convolutionally coded, punctured, and quadrature-modulated, the decoding method provided with
15 (1) a depuncturing step for performing processing reverse to the puncturing and (2) a decoding step for decoding the above punctured quadrature-modulated data; the decoding step comprising (a) a step of calculating a branch metric of the above punctured quadrature-modulated data, (b) a step of estimating an error rate of a signal
20 and adding and comparing it for the calculated branch metric and for selecting a path with reference to the estimated error rate, and (c) a step of outputting a signal matrix in accordance with the selected path; and the error rate estimating step of estimating the error
25 rate comprises (i) a judging step of judging a

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transmission system or coding rate of the signal; (ii) a counting step of counting the number of times of normalization, performed when a state metric is generated, for each of the plurality of transmission systems or coding rates; (iii) an estimating step of estimating the error rate for each signal by the number of times of normalization counted in the counting step; and (iv) a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

According to a 14th aspect of the present invention, there is provided a receiver for receiving and decoding a signal which has been convolutionally coded, punctured, and modulated by a plurality of coding systems or coding rates, the receiver provided with a depuncturing means for performing processing reverse to the puncturing and a decoding means for decoding the above punctured quadrature-modulated data; the decoding means having a branch metric calculating means for calculating a branch metric of the above punctured quadrature-modulated data, an adding, comparing, and selecting means having an error estimating means for estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for selecting a path with reference to the result of estimation by the error estimating means, and a

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path memory means for outputting a signal matrix in accordance with the path selected by the adding, comparing, and selecting means; and the error rate estimating means is provided with a counting means for

5 counting the number of times of normalization, performed when generating a state metric, within a predetermined time, an estimating means for estimating the error rate of the signal by the number of times of normalization counted by the counting means, and a multiplying means

10 for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating means for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying

15 with that value, and an outputting means for adding and outputting the error rate for each signal output from the multiplying means.

According to a 15th aspect of the present invention, there is provided a decoding method for decoding a signal

20 which has been convolutionally coded, punctured, and modulated by a plurality of modulation systems or coding rates, the decoding method provided with (1) a depuncturing step for performing processing reverse to the puncturing and (2) a decoding step for decoding the

25 above punctured quadrature-modulated data; the decoding

step comprising (a) a step of calculating a branch metric of the above punctured quadrature-modulated data, (b) a step of estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for
5 selecting a path with reference to the estimated error rate, and (c) a step of outputting a signal matrix in accordance with the selected path; and the step of estimating the error rate of the signal comprises (i) a counting step of counting the number of times of
10 normalization, performed when generating a state metric, for each of a plurality of transmission systems or coding rates, (ii) an estimating step of estimating an error rate for each signal by the number of times of normalization counted by the counting step, (iii) a
15 multiplying step of determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding
20 rates and multiplying with that value, and (iv) an outputting step of adding and outputting the error rate for each signal output in the multiplying step.

BRIEF DESCRIPTION OF THE DRAWINGS

25 Figure 1 is a block diagram of the configuration of

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25 Figures 14A to 14D are timing charts for explaining

an operation of the accumulator of Fig. 13.

Figures 15A and 15B are views of a table stored in the table of Fig. 12.

Figure 16 is a block diagram of the configuration of the ACS circuit of the present invention.

Figure 17 is a block diagram of the configuration of the monitoring circuit to which the present invention is applied.

Figure 18 is a block diagram of the configuration of a normalization accumulator in Fig. 17.

Figures 19A to 19D are timing charts for explaining the operation of the normalization accumulator in Fig. 18.

Figures 20A and 20B are views of a table stored in the table of Fig. 17.

Figures 21A and 21B are views of a table stored in the table of Fig. 17.

Figure 22 is a block diagram of another configuration of the monitoring circuit.

Figure 23 is a graph illustrating the function of the function processor of Fig. 22.

Figure 24 is a view for explaining a frame structure of a different coding rate.

Figure 25 is a view for explaining another configuration of the decoder.

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Figure 26 is a block diagram of the configuration of the monitoring circuit of Fig. 25.

Figure 27 is a block diagram of the configuration of the normalization accumulator of Fig. 26.

5 Figures 28A to 28F are timing charts for explaining an operation of the normalization accumulator of Fig. 27.

Figure 29 is a block diagram of another example of the configuration of the monitoring circuit.

10 Figure 30 is a block diagram of still another example of the configuration of the monitoring circuit.

Figure 31 is a view of the configuration of the selector of Fig. 30.

Figure 32 is a view of the configuration of the selector of Fig. 30.

15 Figure 33 is a view of a table stored in the selector of Fig. 30.

Figure 34 is a view of a table stored in the selector of Fig. 30.

20 Figure 35 is a block diagram of the configuration of the monitoring circuit and the receiver when simultaneously receiving signals of different coding rates.

Figure 36 is a block diagram of the configuration of the monitoring circuit of Fig. 35.

25 Figure 37 is a view of a table stored in the

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selector of Fig. 36.

Figure 38 is a view explaining the hardware configuration when realizing the coding processing by software.

5 Figure 39 is a view explaining the hardware configuration when realizing the decoding processing by software.

BEST MODE FOR CARRYING OUT THE INVENTION

10 A transmitter and receiver to which the present invention is applied are basically configured the same as in the configuration shown in Fig. 1, therefore explanations thereof are omitted. The method of judging the error rate on the channel performed at the receiver
15 side in the present invention differs from that explained above. First, the configuration of the ACS circuit 32 of the decoder 9 will be explained with reference to Fig. 16.

20 Figure 16 is a block diagram of the configuration of the ACS circuit 32 for performing normalization using the data of the upper bits of the state metrics of all states to find a state metric. The most significant bit of the N number of bits of data output from the state 00
25 generating unit 41 for generating the state metric of the state 00 is input to the register 48-1 through an EXOR

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as well. Data output from the register 48-3 is supplied to the path memory 33, while the most significant bit is supplied to the AND circuit 82.

Further, the most significant bit of the N number of
5 bits of data output from the state 11 generating unit 44
is input to the register 48-4 through the EXOR circuit,
while the N-1 number of bits other than the most
significant bit is input to the register 48-4 without
going through the EXOR circuit. Data output from the AND
10 circuit 82 is input to the EXOR circuit 81-4 as well.
Data output from the register 48-4 is supplied to the
path memory 33, and the most significant bit is supplied
to the AND circuit 82.

The AND circuit 82 outputs 1 when all of the most
15 significant bits of data output from the registers 48-1
to 48-4 are 1 and outputs 0 at other times. When the
values of the state metrics of the states gradually
increase and the most significant bit of the minimum
state metric becomes 1, it uses an exclusive OR operation
20 (EXOR circuits 81-1 to 81-4) to make the most significant
bits of the state metrics of all states 0 for
normalization.

Figure 17 is a block diagram of the configuration of
the monitoring circuit 11. The monitoring circuit 11 is
25 comprised of a normalization accumulator 91 and a table

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92. The normalization information is input from the ACS circuit 32 to the normalization accumulator 91. The normalization information is information output to the monitoring circuit 11 each time the normalization is performed by the ACS circuit 32.

Figure 18 is a block diagram of the configuration of the normalization accumulator 91. The normalization accumulator 91 is comprised of a timer 101, a normalization cumulative counter 102, and a register 103. Normalization information output from the ACS circuit 32 is input to the normalization cumulative counter 102. A pulse generated by the timer 101 every predetermined time is input to the normalization cumulative counter 102 as well. The pulse generated by the timer 101 is output to the register 103 as well. The output from the normalization cumulative counter 102 is input to the register 103 as well.

The operation of the normalization accumulator 91 shown in Fig. 18 will be explained referring to the timing chart in Figs. 19A to 19D. As shown in Fig. 19A, a pulse is generated for every time unit by the timer 101, and the generated pulse is supplied to the normalization cumulative counter 102 and the register 103. As shown in Fig. 19B, the normalization cumulative counter 102 counts the number of times of input when the normalization

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information is output from the ACS circuit 32. In the example shown in Figs. 19A to 19D, eight times of normalization information are input during one time unit.

The normalization cumulative counter 102 outputs the
5 counter value to the register 103 and resets its value to
0 (Fig. 19D) for every pulse supplied from the timer 101.
In this way, the counter value output to and stored in
the register 103 is output to the table 92 when the pulse
from the timer 101 is input.

10 Figures 20A and 20B are views of examples of tables
stored by the table 92. The table shown in Figs. 20A and
20B shows the correspondence between the counter value
(count) output from the register 103 of the normalization
accumulator 91 and the value of the transmission error
rate (BER: bit error rate) of the channel 6 estimated
15 from the count. Figure 20A is a table in the case where
the transmission system is the QPSK system and the coding
rate R is 1/2, while Fig. 20B is a table in the case
where the transmission system is the QPSK system and the
20 coding rate R is 3/4.

For instance, in the case where the transmission system is the QPSK system and the coding rate R is $1/2$, when the count supplied from the register 103 is 355 or more, the value output as the error rate information 12

25 of the channel 6 (Fig. 1) is 0.50×10^{-3} . In the same

way, a value calculated based on the table from the transmission system, coding rate, and a value corresponding to the count is output as the error rate information 12.

5 Figures 21A and 21B show tables in the case where
the CN ratio (carrier to noise ratio) is output as the
error rate information 12. Figure 21A is a table when the
transmission system is the QPSK system and the coding
rate R is 1/2, while Fig. 21B is a table when the
10 transmission system is the QPSK system and the coding
rate R is 3/4. For instance, in the case where the
transmission system is the QPSK system and the coding
rate R is 1/2, when the count supplied from the register
103 is 355 or more, the value output as the error rate
15 information 12 of the channel 6 is 3.00 (dB).

Figure 22 is a block diagram of another configuration of the monitoring circuit 11. The monitoring circuit 11 shown in Fig. 22 is comprised of the normalization accumulator 91 and a function processor 111. The function processor 111 estimates the error rate information 12 without using the tables shown in Figs. 20A and 20B and Figs. 21A and 21B, but by using the function f calculated from these tables.

In the table shown in Fig. 20A in the case where the
25 transmission system is the QPSK system and the coding

5 the count is reduced by 10 from 350 to 340, the value of
BER increases by about four times. Calculating the
equation used in the function processor 111 considering
this fact gives the following equation (1):

$$f(\text{input}) = 0.0005 \times 4^{((360 - \text{input})/10)} \quad (1)$$

10 In equation (1), the above "input" shows the count input
from the normalization accumulator 91.

Note that in equation (1), the range of the count
able to be used as input is from 335 to 354. When the
count is 334 or less, 0.2×10^{-1} is output as the error
rate information 12, while when the count is 355 or more,
 0.5×10^{-3} is output as the error rate information 12.

This is because a difference arises between the value obtained from the function f and the value used when preparing a table (function f no longer followed).

20 In this way, in the practical range, the function f is used in the range where there is no problem, while a value based on the count is output in other ranges.

In the same way, the following equation (2) is derived as a function f corresponding to the table of

25 Fig. 20B in the case where the transmission system is the

QPSK system and the coding rate is 3/4:

$$f(\text{input}) = 0.0033 \times 3^{((580-\text{input})/10)} \quad (2)$$

In equation (2), the range of the count able to be used as the input is 545 to 565. When the count is 544 or
5 less, 1.90×10^{-1} is output as the error rate information 12, while when the count 565 or more, 4.80×10^{-3} is output as the error rate information 12.

The following equation (3) is derived as a function f corresponding to the table shown in Fig. 21A in the
10 case where the transmission system is the QPSK system and the coding rate is 1/2.

$$f(\text{input}) = 0.05^{(\text{input}-300)} \quad (3)$$

In equation (3), the range of the count able to be used as the input is 335 to 355. When the count is 334 or
15 less, 1.50 is output as the error rate information 12, while when the count is 355 or more, 3.00 is output as the error rate information 12.

The following equation (4) is derived as a function f corresponding to the table shown in Fig. 21B in the
20 case where the transmission system is the QPSK system and the coding rate is 3/4.

$$f(\text{input}) = 0.025^{(\text{input}-500)} \quad (4)$$

In equation (4), the range of the count able to be used as the input is 544 to 565. When the count is 544 or
25 less, 0.85 is output as the error rate information 12,

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while when the count is 565 or more, 2.20 is output as the error rate information 12.

Figure 23 shows the relation between data serving as the basis when preparing a table and a graph obtained by any one equation among equations (1) to (4). As will be understood from Fig. 23, equations (1) to (4) approximate the values of the table within the dotted lines. Outside of the dotted lines, since the equations do not approximate to the values of the table, as described above, the error rate information 12 is not obtained using equations (1) to (4), but a predetermined value is output. Note that in practice, if the BER or C/N value obtained by equations (1) to (4) is sufficient, it is possible not to output the error rate information 12 outside the range obtained by equations (1) to (4).

In the above explanation, the case where the transmission system was the QPSK system and the coding rate R was either of $1/2$ or $3/4$ was explained, but different transmission systems or coding rates R are mixed in some cases. For example, as shown in Fig. 24, the following explanation will be given taking as an example the case where the transmission system is the QPSK system, but the coding rate R is a mixture of $1/2$ and $3/4$.

Figure 25 is a block diagram of the configuration of

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the decoder 9 and the monitoring circuit 11 in the case where different coding rates R are mixed together. In this configuration, the monitoring circuit 11 receives as input information relating to the coding rate R from the bit insertion unit 8 (Fig. 1). The bit insertion unit 8 judges the coding rate R , outputs a signal as is to the decoder 9 when a signal of a coding rate R of $1/2$ is input, and inserts bits by depuncturing and then outputs the signal to the decoder 9 when a signal of a coding rate R of $3/4$ is input. The monitoring circuit 11 receives as input information of the judged coding rate R .

Figure 26 is a block diagram of the configuration of the monitoring circuit 11 shown in Fig. 25. The normalization accumulator 91 in this configuration receives as input the normalization information from the ACS circuit 32 and the coding rate information from the bit insertion unit 8.

Figure 27 is a block diagram of the configuration of the normalization accumulator 91 shown in Fig. 26. In this configuration, the timer 101 and the normalization cumulative counter 102 receive as input the coding rate information. The normalization cumulative counter 102 also receives as input the normalization information and the pulses output from the timer 101. The register 103

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receives as input the output from the normalization cumulative counter 102 and the pulses from the timer 101.

The operation of the normalization accumulator 91 shown in Figs. 28A to 28F will be explained next

5 referring to the timing chart of Fig. 27. The explanation will be made of the case where the transmission system is the QPSK system, but the coding rate R is changed in the order of $1/2$, $3/4$, and $1/2$ as shown Fig. 28A and the case where a pulse is generated at the timer 101 as shown in
10 Fig. 28B. The interval between the pulse generated at the timer 101 at a predetermined time and the pulse the next time is defined as one time unit.

Here, for instance, if the coding rate information is made 1 when the coding rate R is $1/2$ and is made 0
15 when the coding rate R is $3/4$, when the coding rate R changes as shown in Fig. 28A, the coding rate information becomes as shown in Fig. 28C. Further, as shown in Fig. 28D, when the normalization information is input a total of eight times in a time unit, that is, six times when
20 the coding rate R is $1/2$ and two times when the coding rate R is $3/4$, in the normalization cumulative counter 102, the normalization cumulative counter 102 counts only the number of times of normalization at the same coding rate R , in the other words, only the number of times of
25 normalization when the coding rate information is 1.

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That is, in the example shown in Fig. 28E, only the number of times of normalization when the coding rate R is $1/2$ is counted, so the value output to the table 92 from the register 103 as the number of times of

5 normalization number for one time unit becomes six.

The table 92 uses the value input in this way and the stored table to calculate and output the error rate information 12. As the tables which the table 92 stores, the table shown in Figs. 20A and 20B or the table shown
10 in Figs. 21A and 21B may be used. Further, it is possible to find the error rate information 12 from the function f .

Figure 29 is a block diagram of another configuration of the monitoring circuit 11 for estimating
15 the error rate information 12 when different transmission systems or coding rates R are mixed together. In this configuration, the error rate information 12 is estimated separately for the signals with the coding rate R of $1/2$ and the signals with the coding rate R of $3/4$. A
20 normalization accumulator 91-1 and a normalization accumulator 91-2 receive as input normalization information from the ACS circuit 32. The coding rate information from the bit insertion unit 8 is supplied to the normalization accumulator 91-2 and the selector 122
25 and is also supplied to the normalization accumulator

91-1 through a NOT circuit 121. The coding rate information input to the normalization accumulator 91-1 is input through the NOT circuit 121, so information opposite to that of the normalization accumulator 91-2 is input.

The information output from the normalization accumulator 91-1 is input to the table 92-1, while the information output from the normalization accumulator 91-2 is input to the table 92-2. The information output from the table 92-1 and table 92-2 is input to the selector 122. The selector 122 selects and outputs one of the information input from the tables 92-1 and 92-2 based on the input coding information.

The normalization accumulator 91-1 and the normalization accumulator 91-2 are configured as shown in Fig. 12. The normalization accumulator 91-1 counts the number of times of normalization input when the coding rate information is of the coding rate R of $1/2$, while the normalization accumulator 91-2 counts the number of times of normalization input when the coding rate information is of the coding rate R of $3/4$. As explained above, since the mutually opposite coding rate information input to the normalization accumulator 91-1 and the normalization accumulator 91-2 are input, when one of the number of times of normalization is being

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counted, the other is not counted.

The numbers of times of normalization counted by the normalization accumulators 91-1 and 91-2 in this way are output to the corresponding tables 92-1 and 92-2. The
5 table 92-1 stores the tables shown in Fig. 20A and Fig. 21A, while the table 92-2 stores the tables shown in Fig. 20B and Fig. 21B. The tables 92-1 and 92-2 estimate the error rate information 12 according to the tables they store and output the results to the selector 122. The
10 selector 122 selects the input from the tables 92-1 and 92-2 corresponding to the coding rate which the input coding rate information indicates and outputs the same as the error rate information 12.

Figure 30 is a block diagram of another
15 configuration of the monitoring circuit 11. The selector 131 of this configuration selects and outputs an input from the tables 92-1 and 92-2 without using the coding information. The configuration of the selector 131 is shown in Fig. 31. The selector 131 stores the constant C.
20 This constant C and the input value are compared to determine the output information. That is, when the input 0 is made the input from the table 92-1 and the input 1 is made the input from the table 92-2, the input 0 is output as the error rate information 12 if input 0 is
25 larger than the constant C, while the input 1 is output

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as the error rate information 12 if the input 0 is equal to or less than the constant C.

Figure 32 is a block diagram of another configuration of the selector 131. The selector 131

5 outputs a value giving a predetermined weight to the
input value. the multiplier 141-1 receives as input
information from the table 92-1, while the multiplier
141-2 receives as input the information from the table
92-2. The multipliers 141-1 and 141-2 multiply the values
0 input to them with a predetermined value and output the
results to an adder 142. The adder 142 adds and outputs
the sum of the input values.

Figure 33 is a table showing weighting values to be multiplied by the multipliers 141-1 and 141-2. The table is stored in a not shown storage unit and is supplied to the multipliers 141-1 and 141-2 of the selector 131 in accordance with need. The table is a table corresponding to the table shown in Figs. 21A and 21B. The value for the weighting is determined based on the error rate

20 information 12 of the coding rate $R=1/2$ (information
output from the table 91-1). For instance, when
information from the table 92-1 input to the multiplier
141-1 is 2.5, 1.0 is supplied as the weighting value to
the multiplier 141-1 and 0.0 is supplied as the weighting
25 value to the multiplier 141-2.

In the above explanation, the tables 92-1 and 92-2 estimated the error rate information 12 from the stored tables, but it is also possible to estimate this using the above functions. Namely, it is also possible to use a function processor using the function of equation (3) instead of the table 92-1 and use a function processor using a function of equation (2) instead of the table 92-2.

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simultaneously receiving and processing two or more signals transmitted by different transmission systems (coding rates) will be explained. Figure 35 is a block diagram of the configuration of a receiver including a monitoring circuit 11 which simultaneously receives and processes two or more signals transmitted by different transmission systems. The monitoring circuit 11 receives as input normalization information from the decoders 9 and 9'.

Figure 36 is a block diagram of the configuration of the monitoring circuit 11 of Fig. 35. The normalization accumulator 91-1 receives as input the normalization information of the encoder 9, while the normalization accumulator 91-2 receives as input the normalization information of the coder 9'. The information output from the normalization accumulator 91-1 is input to the table 92-1, while the information output from the normalization accumulator 91-2 is input to the table 92-2. The information output from the tables 92-1 and 92-2 are input to the selector 131.

The normalization accumulators 91-1 and 91-2 are configured is shown in Fig. 3. The normalization accumulator 91-1 cumulatively adds the number of times of normalization for a signal of a coding rate R of $1/2$, while the normalization accumulator 91-2 cumulatively

adds the number of times of normalization of a signal of
a coding rate R of $3/4$. The table 92-1 stores the table
of Fig. 21A, while the table 92-2 stores the table of
Fig. 21B. The selector 131 is configured as shown in Fig.
5 32, stores the table shown in Fig. 37, weights the input
value based on the stored table, and outputs the result.

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The table shown in Fig. 37 shows a table in the case
of weighting based on an estimated value of the error
10 rate information 12 for a coding rate $R=3/4$ (information
output from the table 92-2). For instance, when the
estimated value output from the table 92-2 is 2.5, the
selector 131 multiplies 1.0 with the estimated value
input from the table 92-1 based on the table shown in
15 Fig. 37, multiplies 0.0 with the estimated value input
from the table 92-2, adds the values, and outputs the
result.

As described above, since the error rate on the
channel is calculated based on the number of times of
20 normalization performed in the ACS circuit 32 for finding
the state metric, the circuit can be made smaller and
simpler. It is also possible to properly estimate the
error rate information for a signal transmitted by
different transmission systems or coding rates.

25 Next, an explanation will be given, using Fig. 38,

of the hardware configuration of the transmitter 1 in the case of coding processing explained using Fig. 1 to Fig. 37 by software.

In Fig. 38, the transmitter 1 is provided with a CPU
5 (central processing unit) 1001 for executing a processing program, a ROM (read only memory) 1002 storing a processing program for processing in accordance with a coding routine explained using Fig. 1 to Fig. 37, a RAM (random access memory) 1003 temporarily storing
10 processing data, an external storage 1004 storing data to be coded and transmitted, and a communications I/F (interface) 1005 for transmitting an I-signal and Q-signal of a signal point through the channel 6 to the receiver 7. Further, it is provided with a path 1006
15 connected to the circuits for transmission of the program or data.

The external storage 1004 is a randomly accessible information storage medium such as a magnetic disk or optical disk.

20 Note that the processing program of the present embodiment is stored in the ROM 1002 in this configuration, but it is also possible to have it stored in an external storage 1004 and to transfer it through the bus 1006 to the RAM 1003 at the time of execution and
25 execute it by the CPU 1001. Further, it is also possible

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to configure the communications I/F 1005 to be able to transmit and receive a signal, have the processing program received by the communications I/F 1005 from the external storage through the channel, store it in the RAM
5 1003 or the external storage 1004, and execute it at the CPU 1001.

That is, the transmitter 1 may introduce the computer program for the above processing for processing at the CPU 1001 through not only a medium comprised of a
10 magnetic disk, CD-ROM, or other information storage medium, but also the Internet, digital satellite, or other transmission medium.

An explanation will be given, using Fig. 39, of the hardware configuration of the receiver 1 in the case of
15 decoding processing explained using Fig. 1 to Fig. 37 by software.

In Fig. 39, the receiver 7 is provided with a CPU (central processing unit) 2001 for executing a processing program, a ROM (read only memory) 2002 storing a
20 processing program for processing in accordance with a decoding routine explained using Fig. 1 to Fig. 37, a RAM (random access memory) 2003 temporarily storing processing data, an external storage 2004 storing data to be decoded, that is, decoding information 10, and a
25 communications I/F (interface) 2005 for receiving an I-

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signal and Q-signal from the transmitter 1 through the channel 6. Further, it is provided with a path 2006 connected to the circuits for transmission of the program or data.

- 5 The external storage 2004 is a randomly accessible information storage medium such as a magnetic disk or optical disk.

- Note that the processing program of the present embodiment is stored in the ROM 2002 in this
- 10 configuration, but it is also possible to have it stored in an external storage 2004 and to transfer it through the bus 2006 to the RAM 2003 at the time of execution and execute it by the CPU 2001. Further, it is also possible to configure the communications I/F 2005 to be able to
- 15 transmit and receive a signal, have the processing program received by the communications I/F 2005 from the external storage through the channel, store it in the RAM 2003 or the external storage 2004, and execute it at the CPU 2001.

- 20 That is, the receiver 7 may introduce the computer program for the above processing for processing at the CPU 2001 through not only a medium comprised of a magnetic disk, CD-ROM, or other information storage medium, but also the Internet, digital satellite, or
- 25 other transmission medium.

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As explained above, according to the above embodiment using the error rate estimating device, the error rate estimating method, and the medium of the present invention, since the number of times of normalization performed when generating a state metric is counted within a predetermined time and the error rate of a signal is estimated by the counted number of times of normalization, the device for estimating the error rate of the signal can be made smaller in configuration and can perform processing at a high speed.

Further, according to the above embodiment using the error rate estimating device, the error rate estimating method, and the medium of the present invention, since the number of times of normalization performed when generating a state metric is counted for each of a plurality of transmission systems or coding rates and the error rate for each signal is estimated by the counted number of times of normalization, the device for estimating the error rate of the signal can be made smaller in configuration and can perform processing at a high speed.

Further, according to the above embodiment utilizing the error rate estimating device, error rate estimating method, and medium of the present invention, since the number of times of normalization performed when

generating a state metric is counted for each of a plurality of transmission systems or coding rates, the error rate for each signal is estimated by the counted number of times of normalization, a value to be

5 multiplied with an error rate for each signal is determined in accordance with the value of the error rate estimated by the estimating means for a predetermined transmission system or coding rate and multiplied, and the value is added and output, the device for estimating

10 the error rate of the signal can be made smaller in configuration and can perform processing at a high speed.

INDUSTRIAL APPLICABILITY

The error rate estimating device and the error rate estimating method of the present invention may be applied

15 to various apparatuses for transmitting signals.

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CLAIMS

1. An error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal,
- 5 the error rate estimating device provided with counting means ~~(91, 101, 102, 103)~~ for counting the number of times of normalization, performed when generating a state metric within a predetermined time and an estimating means (92, 111) for estimating
- 10 the error rate of the signal by the number of times of normalization counted by the counting means.
2. An error rate estimating device as set forth in claim 1, wherein the estimating means estimates the error rate based on a table establishing correspondence between
- 15 the number of times of normalization and the error rate on a channel.
3. An error rate estimating device as set forth in claim 1, wherein the estimating means inserts the number of times of normalization counted by the counting means
- 20 into a predetermined function.
4. An error rate estimating device as set forth in claim 1, wherein the counting means counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined
- 25 coding rate.

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5. An error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal,

said error rate estimating method comprising:

5 a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimating step of estimating the error rate of the signal by the number of times of normalization counted in the counting step.

6. An error rate estimating method as set forth in claim 5, wherein in the estimating step, the error rate is estimated based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

7. An error rate estimating method as set forth in claim 5, wherein in the estimating step, the number of times of normalization counted in the counting step is inserted into a predetermined function.

8. An error rate estimating method as set forth in claim 5, wherein in the counting step, only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate is counted.

9. An information providing medium for providing

information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein said control information includes:

5 a count instruction for counting the number of
times of normalization, performed when generating a state
metric, within a predetermined time and

an estimation instruction for estimating the error rate of the signal by the number of times of normalization counted when said count instruction is executed.

10. An information providing medium as set forth in claim 9, wherein the estimation instruction estimates the error rate based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

11. An information providing medium as set forth in claim 9, wherein the estimation instruction inserts the number of times of normalization counted by the counting means into a predetermined function.

12. An information providing medium as set forth in claim 9, wherein the count instruction counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate.

13. An error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

5 said error rate estimating device provided
with:

a judging means (62) for judging a transmission system or coding rate of the signal;

a counting means (91) for counting the number
10 of times of normalization, performed when generating a
state metric, for each of the plurality of transmission
systems or coding rates;

an estimating means (92, 111) for estimating
the error rate for each signal by the number of times of
15 normalization counted by the counting means; and

a selecting means (32, 33) for selecting one of a plurality of error rates for each signal estimated by the estimating means.

14. An error rate estimating device as set forth in
20 claim 13, wherein said selecting means selects the error
rate according to the transmission system or the coding
rate judged by the judging means.

15. An error rate estimating device as set forth in claim 13, wherein the selecting means selects an error rate to be output by comparing a plurality of error rates

16. An error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, said error rate estimating method comprising:

a counting step of counting the number of times
10 of normalization, performed when a state metric is
generated, for each of the plurality of transmission
systems or coding rates;

a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

18. An error rate estimating method as set forth in claim 16, further comprising, in said selecting step, selecting an error rate to be output by comparing a

plurality of error rates input with a predetermined reference value.

19. An information providing medium for providing information for control executed by a receiver receiving
5 a signal modulated by a plurality of transmission systems or coding rates sent through a channel, wherein said control information includes:

a judgement instruction for judging a transmission system or coding rate of the signal;
10 a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time;

an estimation instruction for estimating the error rate of the signal by the number of times of
15 normalization counted in said count step; and

a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

20. An error rate estimating device for estimating
20 an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating device comprising:
a counting means (91) for counting the number
25 of times of normalization, performed when generating a

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state metric, for each of the plurality of transmission systems or coding rates;

an estimating means (92) for estimating the error rate for each signal by the number of times of normalization counted by the counting means;

a multiplying means (111) for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating means for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an outputting means (32, 33) for adding and outputting the error rate for each signal output from the multiplying means.

21. An error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating method comprising:

a counting step of counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimating step of estimating the error rate for each signal by the number of times of normalization

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counted in the counting step;

 a multiplying step of determining a value for
multiplication with the error rate for each signal
according to a value of the error rate estimated by the
5 estimating step for a predetermined transmission system
or coding rate among the transmission systems or coding
rates and multiplying with that value; and

 an outputting step of adding and outputting the
error rate for each signal output in the multiplying
10 step.

22. An information providing medium for providing
information for control executed by a receiver receiving
and decoding a signal modulated by a plurality of
transmission systems or coding rates sent through a
15 channel,

 said control information including:

 a count instruction for counting the number of
times of normalization, performed when generating a state
metric, for each of the plurality of transmission systems
20 or coding rates;

 an estimation instruction for estimating the
error rate for each signal by the number of times of
normalization counted in the counting step;

 a multiplication instruction for determining a
25 value for multiplication with the error rate for each

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signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

5 an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

23. A receiver (6) for receiving and decoding a signal which has been convolutionally coded, punctured,
10 and quadrature-modulated,

 said receiver provided with:

 a depuncturing means (8) for performing processing reverse to said puncturing and

 a decoding means (9) for decoding the above
15 punctured quadrature-modulated data;

 said decoding means having

 a branch metric calculating means (31) for calculating a branch metric of the above punctured quadrature-modulated data,

20 an adding, comparing, and selecting means (32, 11) having an error estimating means (11) for estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for selecting a path with reference to the result of estimation by the error
25 estimating means, and

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a path memory (33) for outputting a signal matrix in accordance with the path selected by said adding, comparing, and selecting means; and

said error rate estimating means (11) is
5 provided with:

a counting means (91) for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimating means (92, 111) for estimating an
10 error rate of said signal by the number of times of normalization counted by said counting means.

24. A receiver as set forth in claim 23, wherein the estimating means estimates the error rate based on a table establishing correspondence between the number of
15 times of normalization and the error rate on a channel.

25. A receiver as set forth in claim 23, wherein the estimating means inserts the number of times of normalization counted by the counting means into a predetermined function.

20 26. A receiver as set forth in claim 23, wherein the counting means counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate.

27. A decoding method for decoding a signal which
25 has been convolutionally coded, punctured, and

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quadrature-modulated,

said decoding method provided with:

a depuncturing step for performing processing
reverse to said puncturing and

5 a decoding step for decoding the above
punctured quadrature-modulated data;

said decoding step comprising

a step of calculating a branch metric of the
above punctured quadrature-modulated data,

10 a step of estimating an error rate of a signal
and adding and comparing it for the calculated branch
metric and for selecting a path with reference to the
estimated error rate, and

a step of outputting a signal matrix in
15 accordance with the selected path; and

said step of estimating the error rate of the
signal comprises

a counting step of counting the number of times
of normalization, performed when generating a state
20 metric, within a predetermined time and

an estimating step of estimating an error rate
of said signal by the number of times of normalization
counted by said counting step.

28. A decoding method as set forth in claim 27,
25 wherein, in the estimating step, the error rate is

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estimated based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

29. A decoding method as set forth in claim 27,
5 wherein, in the estimating step, the number of times of normalization counted in the counting step is inserted into a predetermined function.

30. A decoding method as set forth in claim 27,
wherein, in the counting step, only the number of times
10 of normalization for a signal of a predetermined transmission system or a predetermined coding rate is counted.

31. A receiver (6) for receiving and decoding a
signal which has been convolutionally coded, punctured,
15 and quadrature-modulated,

said receiver provided with:

a depuncturing means (8) for performing
processing reverse to said puncturing and

a decoding means (9) for decoding the above
20 punctured quadrature-modulated data;

said decoding means (9) having

a branch metric calculating means (31) for
calculating a branch metric of the above punctured
quadrature-modulated data,

25 an adding, comparing, and selecting means (11,

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32) having an error estimating means (11) for estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for selecting a path with reference to the result of estimation by the error
5 estimating means, and

a path memory means (33) for outputting a signal matrix in accordance with the path selected by said adding, comparing, and selecting means; and

said error rate estimating means (11) is
10 provided with:

a judging means (62) for judging a transmission system or coding rate of the signal;

a counting means (91) for counting the number of times of normalization, performed when generating a
15 state metric, for each of the plurality of transmission systems or coding rates;

an estimating means (92, 111) for estimating the error rate for each signal by the number of times of normalization counted by the counting means; and

20 a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.

32. A receiver as set forth in claim 31, wherein said selecting means selects the error rate according to
25 the transmission system or the coding rate judged by the

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judging means.

33. A receiver as set forth in claim 31, wherein
the selecting means selects an error rate to be output by
comparing a plurality of error rates input with a
5 predetermined reference value.

34. A decoding method for decoding a signal which
has been convolutionally coded, punctured, and
quadrature-modulated,
said decoding method provided with:
10 a depuncturing step for performing processing
reverse to said puncturing and
a decoding step for decoding the above
punctured quadrature-modulated data;
said decoding step comprising
15 a step of calculating a branch metric of the
above punctured quadrature-modulated data,
a step of estimating an error rate of a signal
and adding and comparing it for the calculated branch
metric and for selecting a path with reference to the
20 estimated error rate, and
a step of outputting a signal matrix in
accordance with the selected path; and
said error rate estimating step of estimating
the error rate comprises
25 a judging step of judging a transmission system

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or coding rate of the signal;

a counting step of counting the number of times of normalization, performed when a state metric is generated, for each of the plurality of transmission

5 systems or coding rates;

an estimating step of estimating the error rate for each signal by the number of times of normalization counted in the counting step; and

10 a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

35. A decoding method as set forth in claim 34, wherein, in the selecting step, an error rate in accordance with the transmission system or coding rate
15 judged by said judging step is selected.

36. A decoding method as set forth in claim 34, wherein, in the estimating step, the error rate output is selected comparing a plurality of input error rates and a predetermined reference value.

20 37. A receiver (6) for receiving and decoding a signal which has been convolutionally coded, punctured, and modulated by a plurality of coding systems or coding rates,

said receiver provided with:

25 a depuncturing means (8) for performing

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processing reverse to said puncturing and

a decoding means (9) for decoding the above
punctured quadrature-modulated data;

said decoding means having

5 a branch metric calculating means (31) for
calculating a branch metric of the above punctured
quadrature-modulated data,

an adding, comparing, and selecting means (11,
32) having an error estimating means (11) for estimating
10 an error rate of a signal and adding and comparing it for
the calculated branch metric and for selecting a path
with reference to the result of estimation by the error
estimating means, and

a path memory means (33) for outputting a
15 signal matrix in accordance with the path selected by
said adding, comparing, and selecting means; and

said error rate estimating means is provided
with:

a counting means (91) for counting the number
20 of times of normalization, performed when generating a
state metric, within a predetermined time,

an estimating means (92, 111) for estimating
the error rate of the signal by the number of times of
normalization counted by the counting means, and

25 a multiplying means (111) for determining a

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value for multiplication with the error rate for each
signal according to a value of the error rate estimated
by the estimating means for a predetermined transmission
system or coding rate among the transmission systems or
5 coding rates and multiplying with that value, and

an outputting means for adding and outputting
the error rate for each signal output from the
multiplying means.

38. A decoding method for decoding a signal which
10 has been convolutionally coded, punctured, and modulated
by a plurality of modulation systems or coding rates,

said decoding method provided with:

a depuncturing step for performing processing
reverse to said puncturing and

15 a decoding step for decoding the above
punctured quadrature-modulated data;

said decoding step comprising

a step of calculating a branch metric of the
above punctured quadrature-modulated data,

20 a step of estimating an error rate of a signal
and adding and comparing it for the calculated branch
metric and for selecting a path with reference to the
estimated error rate, and

a step of outputting a signal matrix in
25 accordance with the selected path; and

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said step of estimating the error rate of the signal comprises

a counting step of counting the number of times of normalization, performed when generating a state
5 metric, for each of a plurality of transmission systems or coding rates,

an estimating step of estimating an error rate for each signal by the number of times of normalization counted by said counting step,

10 a multiplying step of determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding
15 rates and multiplying with that value, and

an outputting step of adding and outputting the error rate for each signal output in the multiplying step.

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ABSTRACT

To reduce the size of the device for judging the error rate on a channel and reducing the amount of processing, a normalization accumulator cumulatively adds the number of times that normalization is performed within a predetermined time in an ACS circuit calculating a state metric. The table stores a table establishing correspondence between the number of times of normalization cumulatively added by the normalization accumulator. The table uses the stored table to judge and output an error rate corresponding to the input cumulative number of times of normalization.

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FIG.1

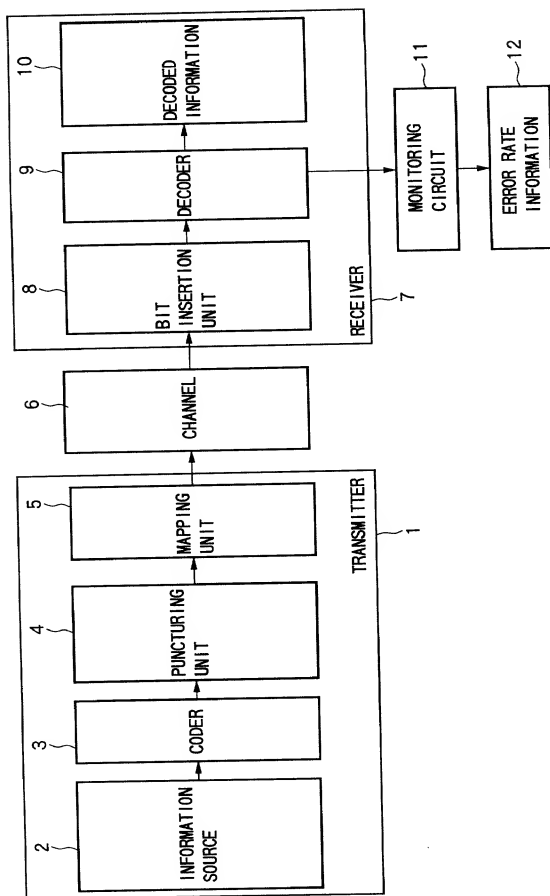


FIG.2

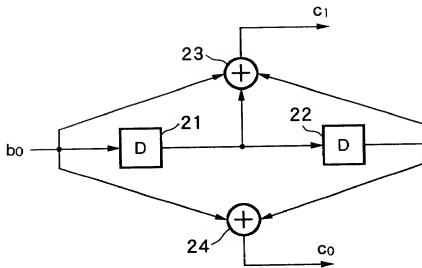
CODER 3

FIG.3A

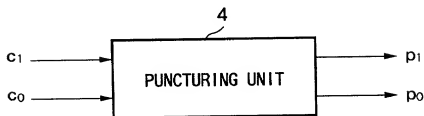
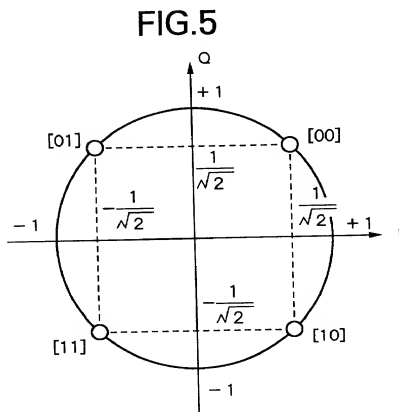


FIG.3B

c ₁	1	1	0
c ₀	1	0	1

FIG.4B OUTPUT

p1	X1	Y3	X4	Y6
p0	Y1	X2	Y4	X5



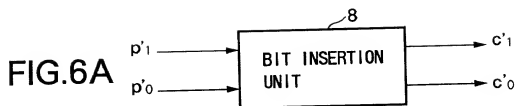


FIG. 6B

DEPUNCTURING TABLE

$p'1$	1	1	0
$p'0$	1	0	1

FIG. 7A

INPUT

$p'1$	X_1	Y_3	X_4	Y_6
$p'0$	Y_1	X_2	Y_4	X_5

FIG. 7B

OUTPUT

$c'1$	X_1	X_2	0	X_4	X_5	0
$c'0$	Y_1	0	Y_3	Y_4	0	Y_6

FIG.8

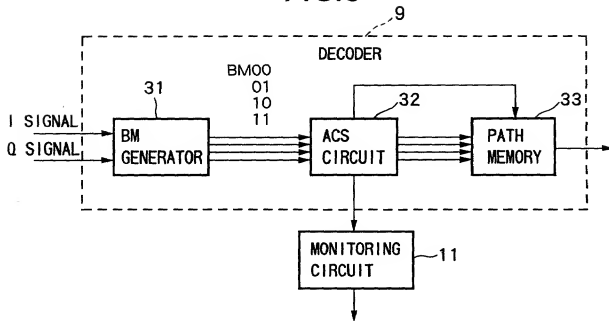


FIG.9

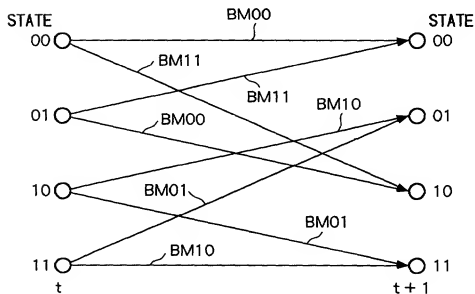


FIG.10

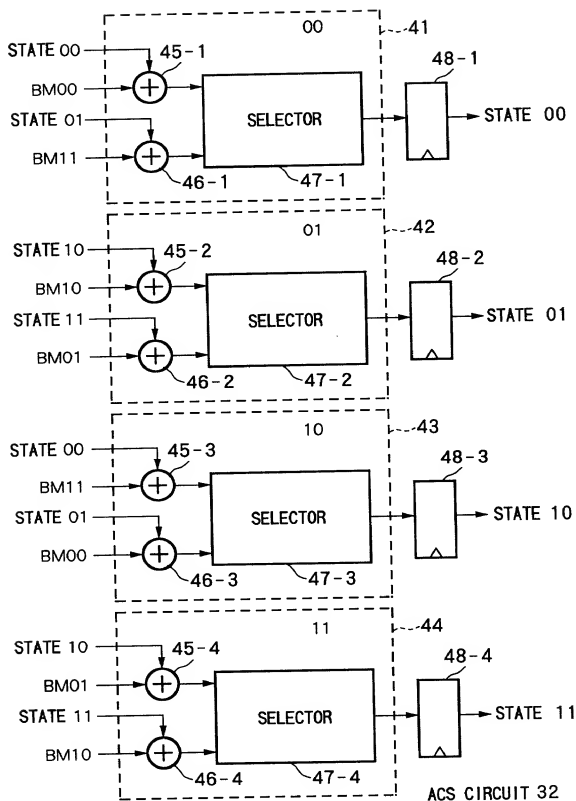


FIG.11

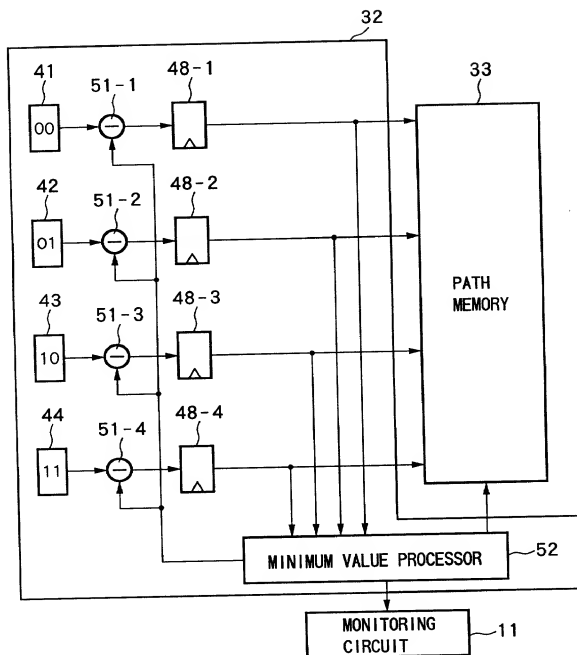


FIG.12

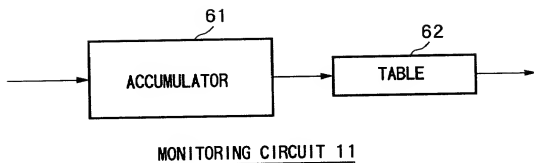
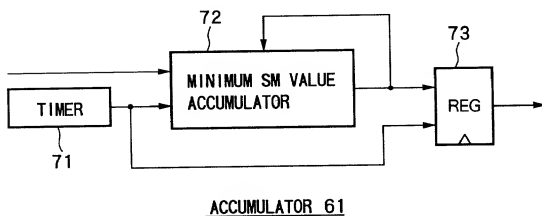


FIG.13



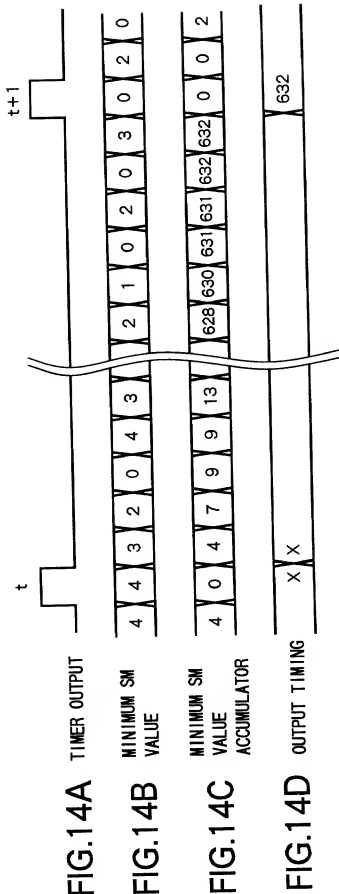


FIG.15A

QPSK R = 1/2	
ROM	
COUNTER VALUE	C/N
EQUAL OR MORE 22720	3.00
EQUAL OR MORE 22080 LESS THAN 22720	2.50
EQUAL OR MORE 21440 LESS THAN 22080	2.00
LESS THAN 21440	1.50

FIG.15B

QPSK R = 3/4	
ROM	
COUNTER VALUE	C/N
EQUAL OR MORE 36160	2.20
EQUAL OR MORE 35520 LESS THAN 36160	1.50
EQUAL OR MORE 34880 LESS THAN 35520	1.00
LESS THAN 34880	0.85

FIG. 16

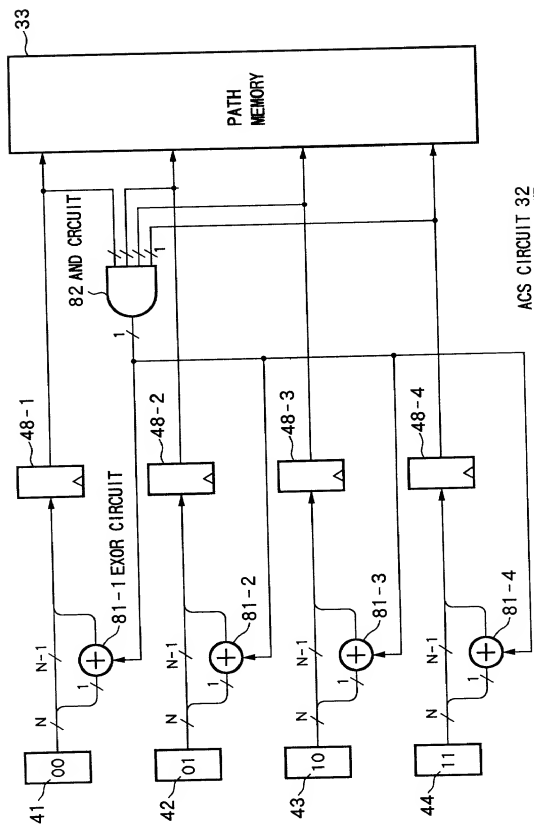


FIG.17

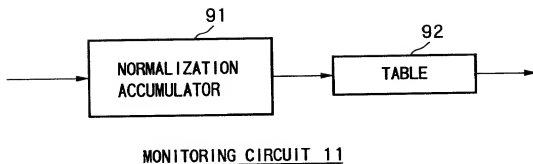
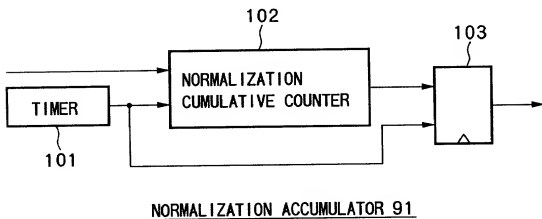
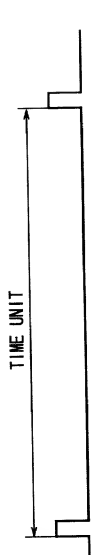


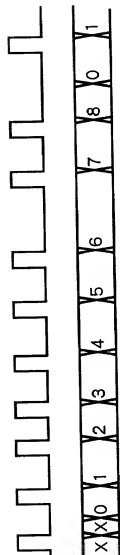
FIG.18





TIMER
OUTPUT

FIG. 19A



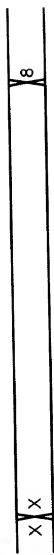
NORMALIZATION
INFORMATION

FIG. 19B



COUNTER

FIG. 19C



OUTPUT

FIG. 19D

FIG.20A

QPSK $R = 1/2$	
COUNTER VALUE	BER
355 OR MORE	0.50×10^{-3}
345 TO 354	1.90×10^{-3}
335 TO 344	0.80×10^{-2}
334 OR LESS	0.20×10^{-1}

FIG.20B

QPSK $R = 3/4$	
COUNTER VALUE	BER
565 OR MORE	4.80×10^{-3}
555 TO 564	3.20×10^{-2}
545 TO 554	1.00×10^{-1}
544 OR LESS	1.90×10^{-1}

FIG.21A

QPSK $R = 1/2$	
COUNTER VALUE	C/N
355 OR MORE	3.00
345 TO 354	2.50
335 TO 344	2.00
334 OR LESS	1.50

FIG.21B

QPSK $R = 3/4$	
COUNTER VALUE	C/N
565 OR MORE	2.20
555 TO 564	1.50
545 TO 554	1.00
544 OR LESS	0.85

FIG.22

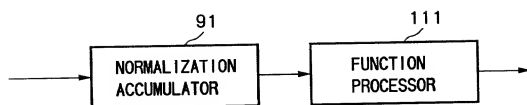
MONITORING CIRCUIT 11

FIG.23

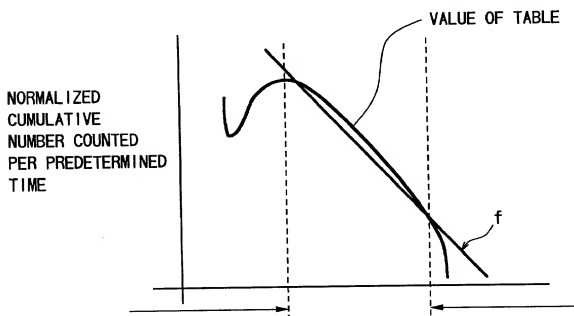


FIG.24

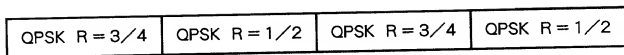


FIG.25

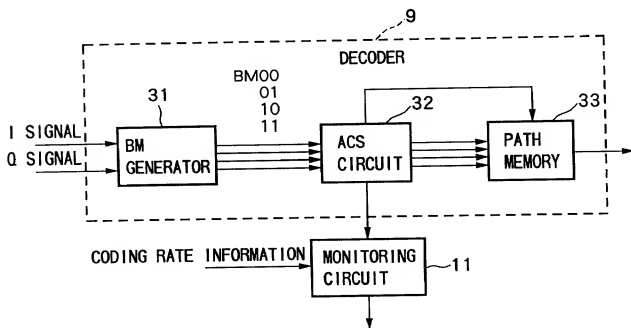


FIG.26

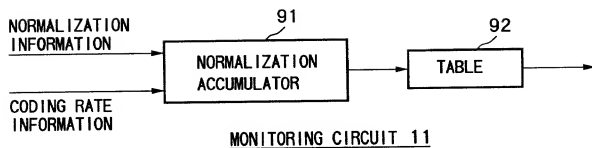


FIG.27

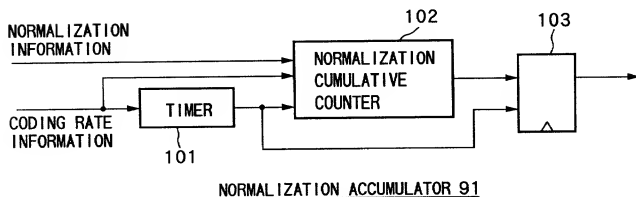


FIG.28A CODING OR MODULATING METHOD

QPSK R = 1/2	QPSK R=3/4	QPSK R = 1/2
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FIG.28B TIMER OUTPUT

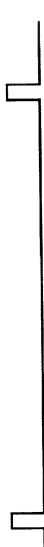


FIG.28C CODING RATE INFORMATION

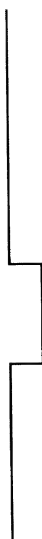


FIG.28D NORMALIZATION INFORMATION



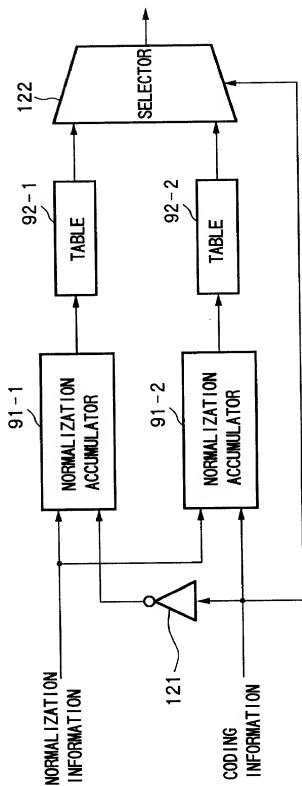
FIG.28E COUNTER



FIG.28F OUTPUT

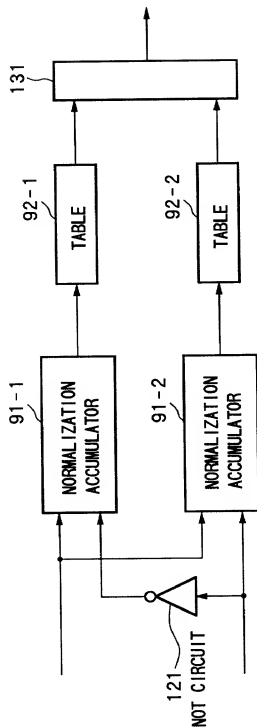


FIG.29



MONITORING CIRCUIT 11

FIG.30



MONITORING CIRCUIT 11

FIG.31

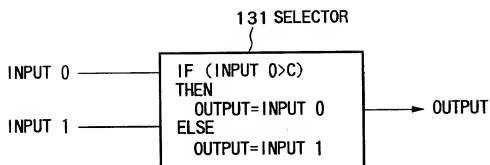


FIG.32

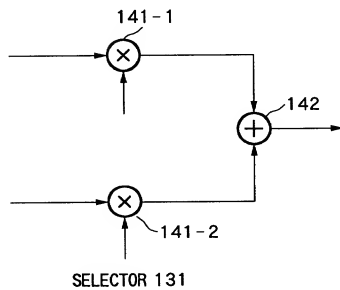


FIG.33

ESTIMATED VALUE OF C/N IN QPSK TRANSMISSION AT $R=1/2$	WEIGHTING(QPSK $R=1/2$)	WEIGHTING(QPSK $R=3/4$)
FROM 2.0[dB] TO 3.0[dB]	1.0	0.0
FROM 1.5[dB] TO 2.0[dB]	0.5	0.5
1.5[dB] OR LESS	0.0	1.0

TABLE

FIG.34

CODING RATE OF QPSK R=3/4	WEIGHTING(QPSK R=1/2)	WEIGHTING(QPSK R=3/4)
EQUAL OR MORE 565	0.0	1.0
EQUAL OR MORE 565 LESS THAN 565	0.5	0.5
LESS THAN 555	1.0	0.0

TABLE

FIG.35

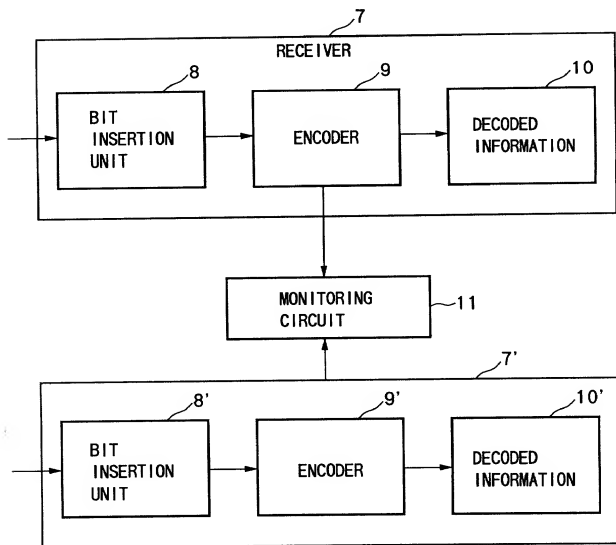


FIG.36

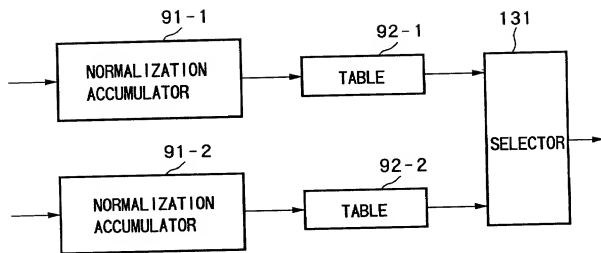
MONITORING CIRCUIT 11

FIG.37

ESTIMATED VALUE OF C/N IN QPSK TRANSMISSION AT R=3/4	WEIGHTING (QPSK R=1/2)	WEIGHTING (QPSK R=3/4)
2.20[dB] OR MORE	1.0	0.0
FROM 1.5[dB] TO 2.20[dB]	0.5	0.5
FROM 0.8[dB] TO 1.5[dB]	0.0	1.0

TABLE

FIG.38

1

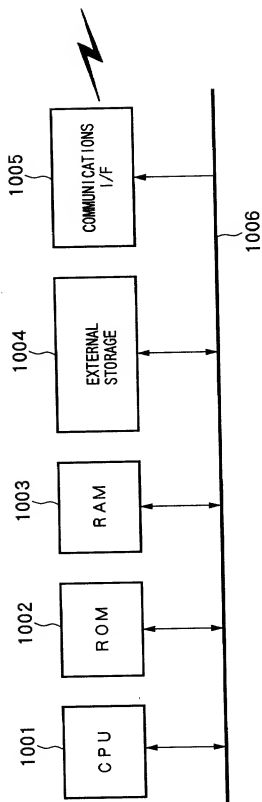
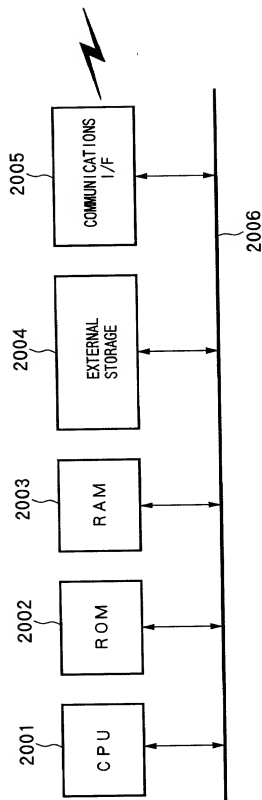


FIG.39

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唯一または第一発明者氏名

発明者の署名

日付

住所

国籍

郵便の宛先

第二共同発明者がある場合、その氏名

第二共同発明者の署名

日付

住所

国籍

郵便の宛先

(第三以下の共同発明者についても同様に記載し、署名をすること)

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特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

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My residence, post office address and citizenship are as stated next to my name:

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I believe I am the original, first and sole inventor if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

ERROR RATE ESTIMATING DEVICE, RECEIVER USING
ERROR RATE ESTIMATING DEVICE, ERROR RATE
ESTIMATING METHOD, RECEIVING METHOD USING
ERROR RATE ESTIMATING METHOD, AND
INFORMATION RECORDING MEDIUM

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☒ was filed on January 5, 2000
as United States Application Number of
PCT International Application Number PCT/JP00/00013
_____ and was amended on
_____ (if applicable).

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Prior Foreign Application(s)

外国での先行出願

11-001790

(Number)
(番号)

Japan

(Country)
(国名)

7 January 1999

(Day/Month/Year Filed)

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☐(Number)
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(国名)

(Day/Month/Year Filed)

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(番号)(Country)
(国名)

(Day/Month/Year Filed)

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(Application No.)
(出願番号)(Filing Date)
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(Application No.)
(出願番号)(Filing Date)
(出願日)(Status: Patented, Pending, Abandoned)
(状況: 特許許可、係属中、放棄)

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